AF/2123

TRANSMITTAL OF APPEAL BRIEF (Large Entity)	Docket No. 200-1452

In Re Application Of: **Paul J. Stewart et al.**

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PATENT & TRADEMARK OFFICE

Application No.	Filing Date	Examiner	Customer No.	Group Art Unit	Confirmation No.
09/681,732	May 30, 2001	T. Stevens	33481	2123	3348

Invention: **SYSTEM AND METHOD FOR DESIGN OF EXPERIMENTS USING DIRECT SURFACE MANIPULATION OF A MESH MODEL**

COMMISSIONER FOR PATENTS:

Transmitted herewith in triplicate is the Appeal Brief in this application, with respect to the Notice of Appeal filed on

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☐ A check in the amount of the fee is enclosed.

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Signature

Dated: November 16, 2005

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Art Unit:	2123	)
Examiner:	T. Stevens	)
Applicant(s):	Paul Joseph Stewart et al.	)
Serial No.:	09/681,732	)
Filing Date:	May 30, 2001	)
For:	SYSTEM AND METHOD FOR DESIGN OF EXPERIMENTS USING DIRECT SURFACE MANIPULATION OF A MESH MODEL	)

APPEAL BRIEF

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Sir:

By Notice of Appeal filed September 16, 2005, Applicants have appealed the Final Rejection dated June 16, 2005 and submit this brief in support of that appeal.

REAL PARTY IN INTEREST

The real party in interest is the Assignee, Ford Global Technologies, Inc.

RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences regarding the present application.

CERTIFICATE OF MAILING: (37 C.F.R. 1.8) I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the U.S. Postal Service with sufficient postage as First Class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450 on November 16, 2005, by Daniel H. Bliss

STATUS OF CLAIMS

Claims 1 through 3 have been canceled.

Claims 4 and 5 have been rejected.

Claims 6 and 7 have been canceled.

Claims 8 through 15 have been rejected.

Claims 16 and 17 have been canceled.

Claims 18 through 20 have been rejected.

Claims 4, 5, 8 through 15, and 18 through 20 are being appealed.

STATUS OF AMENDMENTS

An Amendment Under 37 C.F.R. 1.116 was filed on August 16, 2005 in response to the Final Office Action dated June 16, 2005. An Advisory Action dated September 15, 2005, indicated that the request for reconsideration had been considered, but did not deem to place the application in a condition for allowance. The Advisory Action also indicated that, for purposes of appeal, the Amendment under 37 C.F.R. 1.116 would be entered. A Notice of Appeal, along with the requisite fee, was filed on September 16, 2005. The Appeal Brief, along with the requisite fee, is submitted herewith.

SUMMARY OF THE CLAIMED SUBJECT MATTER

The claimed subject matter is directed to a method for design of experiments using direct surface manipulation of a mesh model. [Referring to FIG. 3, the method 18, according to the present invention, for design of experiments using direct surface manipulation of a mesh model is shown. Preferably, the use of direct mesh modeling expands and integrates a

mathematical surface modeling technique referred to in the art as Direct Surface Manipulation (DSM). With DSM, an entire surface feature is placed on an existing parametric surface as a single geometric entity. After the feature is created, the user 26 can control its location, shape, and continuity independently by adjusting corresponding parameters. This methodology can be applied to allow direct modification of a CAE mesh model in response to a change made to a set of DOE parameters.] (FIG. 3; Specification, page 13, line 9 through 21).

The method includes the step of selecting a base mesh model from an electronic database stored in the memory of the computer system. [In block 205, the user 26 selects a geometric model for assessing its geometric properties, and the model is imported into the methodology. Preferably, the model is a computer generated, computer-aided design (CAD) model, digital buck or other mathematical or geometric representation, that is maintained in a computer database such as a vehicle library 14. The model is represented using a standard data format, such as a set of NURBS, a three-dimensional solid CSG, or a polygonal soup. In one embodiment, the model represents a vehicle and in particular a portion of a body of the vehicle. Further, the user 26 may select a surface representing a section of the model to evaluate such as by drawing a box (not shown) around the desired section of the model to evaluate using a user interactive device 22c such as the mouse.] (FIG. 3; Specification, page 13, line 23 through page 14, line 12).

The method includes the step of selecting a DSM feature from an electronic database stored in the memory of the computer system. [In block 415, the user 26 selects a DSM feature from a DSM feature library maintained in the computer system 22. Preferably, the DSM feature library is a sub-library of the vehicle library 14 containing information relevant to a

particular DSM feature, such as position, orientation, and definition of a feature.] (FIG. 6; Specification, page 23, lines 12 through 17).

The method includes the step of generating a mesh model using the base mesh model and the selected DSM feature. [In block 420, the user 26 specifies a DSM feature and a base mesh to be combined into a mesh model for use in the DOE analysis. For example, the user 26 may select from a list of DSM features displayed on a display device 24b and using an input device 24c, such as a mouse, by pointing to a desired DSM feature and clicking on it. Advantageously, the user 26 specifies how to combine a set of DSM features for a particular DOE analysis. Since the DSM features are saved in a computer database, the user 26 can specify a predetermined combination of DSM features with a base model for each creation of the DOE analysis. In block 425, the methodology uses the selected DSM features and base model to generate a new mesh model. Advantageously, the automatic creation of a mesh model is a time and cost savings since it provides for repeatability of a particular creation of the DOE analysis and the use of a DSM feature as a template in additional analysis. The mesh model is imported into the DOE analysis in block 215 of FIG. 3 and the methodology continues.] (FIGS. 3 and 6; Specification, page 23, line 19 through page 24, line 12).

The method includes the step of evaluating the mesh model using a computer-aided engineering (CAE) analysis. [In block 215, the methodology uses an analysis tool 20 to perform a CAE analysis using predetermined parameters to obtain a response of the system. An example of a CAE analysis is an airflow DOE using computational fluid dynamics. Examples of DOE parameters for the CFD airflow analysis are the windshield angle, whether or not a spoiler is placed on the decklid, and shape of the hood near the windshield. Preferably, the response of

the CAE analysis is provided to the user 26 in a user-defined format, such as graphically displayed on the display device 22b.] (FIG. 3; Specification, page 15, lines 3 through 13).

The method includes the steps of determining whether to continue generating the design of experiments response. [In diamond 220, the user 26 determines whether to continue generating the DOE response. If the user 26 determines to continue the DOE analysis, the methodology advances to block 225.] (FIG. 3; Specification, page 15, lines 15 through 18).

The method also includes the steps of modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model, the mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response. [In block 315, the user 26 defines a two-dimensional workspace or sketch plane for describing a domain of a DSM feature. Preferably, the sketch plane is an analytical surface, which can be oriented relative to the mesh model after it is created. In one embodiment, the sketch plane is a plane tangential to a selected point on the mesh model. As illustrated in FIG. 5a, the mesh model is shown at 500, a selected point at 505, the sketch plane at 510, and a point projected onto the sketch plane at 515. The methodology

advances to block 320. In block 320, the methodology defines a domain of the DSM feature and reference geometry in the sketch plane 510. The domain is a mathematical representation of a closed curve and the boundary of the closed curve defines the area of the domain. The reference geometry is a subset of the domain representing an area of maximum displacement. An example of a reference geometry is an open curve or a single point. As illustrated in FIG.5b, a point defined as a reference center R shown at 520 is located within the domain of the sketch plane 510. A control vector T is centered at R and used to define a height of the feature in object space is shown at 525 in FIG. 5c. Preferably, the user 26 defines the domain and reference geometry using a process referred to in the art as sketching. The methodology advances to block 325. In block 325, the methodology parameterizes an I-th vertex of the mesh, referred to as P_i as shown at 505 onto the sketch plane 510. For example, using a technique referred to in the art as parallel projection, P_i in the form of xyz Cartesian coordinates $x_i y_i z_i$ is projected to the interior of the domain of the DSM feature to obtain its $x_{si} y_{si}$ coordinates as shown at 515. A ray starting from R and passing through the projected point 515 is constructed as shown at 540. The ray will intersect with the domain. The intersection points, shown at 545 and 547, define a line segment shown at 550, which can be parameterized by a single parameter t. Preferably, the domain of t is normalized between 0-1 for mapping a basis function f(t). The methodology advances to block 330. In block 330, the user 26 specifies a maximum displacement V shown at 570 and a basis function f(t) to determine the displacement of P_i. The basis function f(t) is mapped to a line segment bounded by the two intersection points 545, 547. As such, the new location of P_i is the summation of the previous location and the displacement V multiplied by the basis function f(t) as follows:

$$P_i = P_i + \overline{V} f(t(x_s(x_{pi}, y_{pi}, z_{pi}), y_s(x_{pi}, y_{pi}, z_{pi})))$$

The basis function provides for simultaneous modification of all vertices of the triangles within the domain in a direct, intuitive, and controllable manner as illustrated in FIG. 5d at 560. Further, the user 26 can isolate a region on the mesh model and modification is only made to the interior of the region. In addition, transition from the modified region to the remainder is directly controlled by the application of the basis function. The methodology advances to block 335. In block 335, the methodology calculates displacements for all mesh vertices projected within a domain for a feature using the basis function. The methodology advances to block 340. In block 340, the vertices are moved to their new position as shown at 565 in FIG. 5e. In diamond 345, the user 26 determines whether to continue modifying the mesh model. If the user 26 determines not to continue, the methodology advances to block 350. In block 350, the modified mesh model is available for additional use. In one embodiment, the mesh may be refined by decomposing a mesh element lying across the boundary of a feature or inside a feature. This provides a more rational representation of the original mesh model and the new features. In another embodiment, the feature is further manipulated, such as by relocating or modifying. In yet another embodiment, the DSM feature is separated from the original mesh and stored in a DSM feature data sub-library within the vehicle library 14. The DSM feature sub-library contains information relevant to the DSM feature, such as position, orientation, and definition. By combining the DSM feature with the original model of the mesh, the same mesh model is automatically created. This storage provision provides for repeatability of the analysis and can be used for archiving features as a template for later use or for use with another mesh model. The methodology advances to bubble 375 and returns to block 230 of FIG. 3.

Returning to diamond 345, if the user 26 determines to continue, the user 26 modifies a parameter and the methodology continues. For example, if the user 26 determines to

modify the sketch plane, the methodology advances to block 355 and the user 26 modifies the sketch plane. The methodology then returns to block 315 and continues. If the user 26 determines to modify the domain and reference geometry, the methodology advances to block 360 and the user 26 modifies the domain and reference geometry. The methodology then returns to block 325 and continues. If the user 26 determines to modify the projection method, the methodology advances to block 365 and the user 26 modifies the projection method. The methodology then returns to block 320 and continues. If the user 26 determines to modify the basis function parameters or the maximum displacement, the methodology advances to block 370 and the user 26 modifies the maximum displacement or basis function.] (FIG. 4 through 5e; Specification, page 18, line 23 through page 22, line 19).

The method includes the steps of using the results of the CAE analysis for the design of experiments response. [Returning to diamond 220, if the user 26 does not elect to continue generating the DOE response, the methodology advances to block 235. In block 235, the resultant DOE responses are available for further study and evaluation.] (FIG. 3; Specification, page 17, lines 1 through 5).

GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1) The first ground of rejection to be reviewed on appeal is whether the claimed invention of claims 4, 8 through 14, and 18 through 20 is obvious and unpatentable under 35 U.S.C. § 103 over Hirai et al. (U.S. Patent No. 5,734,364) in view of Stewart et al. (U.S. Patent No. 5,903,458).

2) The second ground of rejection to be reviewed on appeal is whether the claimed invention of claims 5 and 15 is obvious and unpatentable under 35 U.S.C. § 103 over

Hirai et al. (U.S. Patent No. 5,734,364) in view of Stewart et al. (U.S. Patent No. 5,903,458) and further in view of Dehmlow et al. (U.S. Patent No. 5,999,187).

ARGUMENT

1) Claims Not Obvious or Unpatentable Under 35 U.S.C. § 103

As to patentability, 35 U.S.C. § 103 provides that a patent may not be obtained:

> If the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Id.

The United States Supreme Court interpreted the standard for 35 U.S.C. § 103 in Graham v. John Deere, 383 U.S. 1, 148 U.S.P.Q. 459 (1966). In Graham, the Court stated that under 35 U.S.C. § 103:

> The scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or non-obviousness of the subject matter is determined. 148 U.S.P.Q. at 467.

Using the standard set forth in Graham, the scope and content of the prior art relied upon by the Examiner will be determined.

As to the primary reference applied by the Examiner, U.S. Patent No. 5,734,364 to Hirai et al. discloses a method of driving a picture display device. FIG. 5c shows the Hadamard's matrix of 7 rows and 8 columns. When (x)=(1, 1, . . . , 1), then, (y)=(7, -1, -1, .., -1) and the

maximum displacement (the maximum value of .DELTA.y.sub.i) is 8. Generally, the difference of the variation of the maximum voltages can be suppressed to a practically applicable extent by determining the above-mentioned reference vectors to be .DELTA.y.sub.MAX1 +.DELTA.y.sub.MAX2 <1.4.multidot.L (hereinafter, referred to as a condition C), more preferably, .DELTA.y.sub.MAX1 +.DELTA.y.sub.MAX.sub.2 .ltoreq.L (hereinbelow, refereed to as a condition D) where .DELTA.y.sub.MAX.sub.1 represents the maximum value of the difference of the variation of the column voltages to the reference pattern 1, and .DELTA.y.sub.MAX.sub.2 represents the maximum value of the difference of the variation of the column voltages to the reference pattern 2.

As to the secondary reference applied by the Examiner, U.S. Patent No. 5,903,458 to Stewart et al. discloses a system and method for forming geometric features using a global reparametrization scheme that allows the formation of DSM features which span multiple surface patches and reduce shape distortion. This scheme provides a single workspace common to the different surface patches thus obtaining a consistent, uniform parametrization. To eliminate the distortion caused by the spatial difference between the object space and parametric space, the common workspace is chosen as a plane residing directly in the object space. Different surface patches can then be reparametrized on the plane using a proper, consistent mapping procedure, thereby resulting in a uniform mesh of these surfaces. The mesh is ultimately substituted into the DSM method for the surface parametric space where DSM features are mapped. The shared workspace provides a common area to geometrically join topologically disconnected surfaces patches through a uniform surface reparametrization. This shared workspace is called the super-mesh space. A point in this space is given in (u.sub.s,v.sub.s) Cartesian coordinates. Surface

patch reparametrization in this space allows us to express surface patches of different UV domain in the same terms of (u.sub.s,v.sub.s) coordinates.

Claims 4 and 8 through 13

Claim 4 claims the present invention as a method for design of experiments using direct surface manipulation of a mesh model. The method includes the steps of selecting a geometric model, wherein the model is in a computer-aided design (CAD) format and converting the geometric model into a mesh model. The method also includes the steps of evaluating the mesh model using a computer-aided engineering (CAE) analysis and determining whether to continue generating the design of experiments response. The method includes the steps of modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. The mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response. The method further includes the steps of using the results of the CAE analysis for the design of experiments.

The United States Court of Appeals for the Federal Circuit (CAFC) has stated in determining the propriety of a rejection under 35 U.S.C. § 103, it is well settled that the obviousness of an invention cannot be established by combining the teachings of the prior art absent some teaching, suggestion or incentive supporting the combination. See In re Fine, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988); Ashland Oil, Inc. v. Delta Resins & Refractories, Inc., 776 F.2d 281, 227 U.S.P.Q. 657 (Fed. Cir. 1985); ACS Hospital Systems, Inc. v. Montefiore Hospital, 732 F.2d 1572, 221 U.S.P.Q. 929 (Fed. Cir. 1984). The law followed by our court of review and the Board of Patent Appeals and Interferences is that " [a] prima facie case of obviousness is established when the teachings from the prior art itself would appear to have suggested the claimed subject matter to a person of ordinary skill in the art." In re Rinehart, 531 F.2d 1048, 1051, 189 U.S.P.Q. 143, 147 (CCPA 1976). See also In re Lalu, 747 F.2d 703, 705, 223 U.S.P.Q. 1257, 1258 (Fed. Cir. 1984) ("In determining whether a case of prima facie obviousness exists, it is necessary to ascertain whether the prior art teachings would appear to be sufficient to one of ordinary skill in the art to suggest making the claimed substitution or other modification.")

As to the differences between the prior art and the claims at issue, the primary reference to Hirai et al. '364 merely discloses a method of driving a picture display device using a Hadamard's matrix, a maximum displacement, and reference vectors. Hirai et al. lacks modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the

DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In Hirai et al. '364, the maximum displacement and reference vectors are used to drive a picture display, but are not used for direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on a surface of a mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model.

The secondary reference to Stewart et al. '458 merely discloses a system and method for forming geometric features using global reparametrization in which a mesh is ultimately substituted into a DSM method for a surface parametric space where DSM features are mapped and the shared workspace provides a common area to geometrically join topologically disconnected surfaces patches through a uniform surface reparametrization. Stewart et al. '458 lacks modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the

DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In Stewart et al. '458, the DSM method for the surface parametric space is used where DSM features are mapped, but does not define a sketch plane containing a domain of a DSM feature, position the sketch plane relative to the surface of the model, locate a reference center within the domain, project a vertex located on a surface of a mesh model into the domain of the sketch plane, specify a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specify a basis function to determine a displacement of the vertex, determine a displacement of the vertex relative to the DSM feature using the basis function, and use the displacement of the vertex to modify the surface of the mesh model.

As to the level of ordinary skill in the pertinent art, in Hirai et al. '364, the maximum displacement and reference vectors are used to drive a picture display. In Stewart et al. '458, the DSM method for the surface parametric space is used where DSM features are mapped. However, there is absolutely no teaching of a level of skill in the vehicle design art that a method for design of experiments using direct surface manipulation of a mesh model includes the steps of converting a geometric model into a mesh mode and modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain

of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. The Examiner may not, because he doubts that the invention is patentable, resort to speculation, unfounded assumptions or hindsight reconstruction to supply deficiencies in the factual basis. See In re Warner, 379 F. 2d 1011, 154 U.S.P.Q. 173 (CCPA 1967).

The Examiner admits on page 3 of the Office Action that Hirai et al. '364 fails to teach applying mathematical tools towards direct surface manipulation (DSM). However, the Examiner speculates that this is taught by Stewart et al. '458 because an improved direct surface manipulation method is disclosed which incorporates a global surface. Stewart et al. '458 discloses a DSM method for the surface parametric space where DSM features are mapped. Contrary to the Examiner's opinion, this DSM method does not teach defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In this instance, the Examiner has adduced no factual basis to support his position that it would have been obvious to one of ordinary skill in the art to modify Hirai et al. '364 by way of Stewart et al.

'458 to improve shape fidelity. The Examiner's stated conclusion of obviousness is based on speculation, unfounded assumptions or hindsight reconstruction to supply deficiencies in the factual basis.

Even if Hirai et al. '364 and Stewart et al. '458 could be combined or modified, it would not teach a method for design of experiments using direct surface manipulation of a mesh model including defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. The references, if combinable, fail to teach or suggest the combination of a method for design of experiments using direct surface manipulation of a mesh model including the steps of selecting a geometric model, wherein the model is in a computer-aided design (CAD) format and converting the geometric model into a mesh model, evaluating the mesh model using a computer-aided engineering (CAE) analysis, determining whether to continue generating the design of experiments response, modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a

reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model, the mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response, and using the results of the CAE analysis for the design of experiments as claimed by Applicants.

Further, the CAFC has held that "[t]he mere fact that prior art could be so modified would not have made the modification obvious unless the prior art suggested the desirability of the modification". In re Gordon, 733 F.2d 900, 902, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984). The Examiner has failed to show how the prior art suggested the desirability of modification to achieve Applicants' invention. Thus, the Examiner has failed to establish a case of prima facie obviousness.

As stated in the Background of the Invention section of the present application, modifying the CAD model in a CAD system is a more time-consuming task that has to be performed each time a change is made to the DOE parameter set. Also, using a CAD system to update the mesh model is a time consuming and costly process. Thus, there is a need in the art for a system and method of direct modification of a mesh model based on DOE parameters using direct surface modeling to eliminate the need to update the CAD model each time a DOE parameter is modified.

The present invention sets forth a unique and non-obvious combination of a method for design of experiments using direct surface manipulation of a mesh model by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the

surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. Advantageously, the method allows a mesh model to be updated using Direct Surface Manipulation after a DOE parameter is varied, instead of updating the CAD model and converting the updated CAD model to a mesh model.

Against this background, it is submitted that the present invention of claims 4 and 8 through 13 is not obvious in view of a proposed combination of Hirai et al. '364 and Stewart et al. '458. The references fail to teach or suggest the combination of the method for design of experiments using direct surface manipulation of a mesh model of claims 4 and 8 through 13. Therefore, it is respectfully submitted that claims 4 and 8 through 13 are not obvious and are allowable over the rejection under 35 U.S.C. § 103.

Claims 14 and 18 through 20

As to claim 14, claim 14 claims the present invention as a method for design of experiments using direct surface manipulation of a mesh model. The method includes the steps of selecting a base mesh model from an electronic database stored in the memory of the computer system and selecting a DSM feature from an electronic database stored in the memory of the computer system. The method also includes the steps of generating a mesh model using the base mesh model and the selected DSM feature, evaluating the mesh model using a computer-aided

engineering (CAE) analysis, and determining whether to continue generating the design of experiments response. The method includes the steps of modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. The mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response. The method further includes the steps of using the results of the CAE analysis for the design of experiments response.

As to the differences between the prior art and the claims at issue, the primary reference to Hirai et al. '364 merely discloses a method of driving a picture display device using a Hadamard's matrix, a maximum displacement, and reference vectors. Hirai et al. lacks modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of

the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In Hirai et al. '364, the maximum displacement and reference vectors are used to drive a picture display, but are not used for direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on a surface of a mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model.

The secondary reference to Stewart et al. '458 merely discloses a system and method for forming geometric features using global reparametrization in which a mesh is ultimately substituted into a DSM method for a surface parametric space where DSM features are mapped and the shared workspace provides a common area to geometrically join topologically disconnected surfaces patches through a uniform surface reparametrization. Stewart et al. '458 lacks modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of

the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In Stewart et al. '458, the DSM method for the surface parametric space is used where DSM features are mapped, but does not define a sketch plane containing a domain of a DSM feature, position the sketch plane relative to the surface of the model, locate a reference center within the domain, project a vertex located on a surface of a mesh model into the domain of the sketch plane, specify a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specify a basis function to determine a displacement of the vertex, determine a displacement of the vertex relative to the DSM feature using the basis function, and use the displacement of the vertex to modify the surface of the mesh model.

There is absolutely no teaching of a level of skill in the vehicle design art that a method for design of experiments using direct surface manipulation of a mesh model includes the steps of converting a geometric model into a mesh mode and modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the

displacement of the vertex to modify the surface of the mesh model. The Examiner may not, because he doubts that the invention is patentable, resort to speculation, unfounded assumptions or hindsight reconstruction to supply deficiencies in the factual basis. See In re Warner, 379 F. 2d 1011, 154 U.S.P.Q. 173 (C.C.P.A. 1967).

The Examiner admits on page 3 of the Office Action that Hirai et al. '364 fails to teach applying mathematical tools towards direct surface manipulation (DSM). However, the Examiner speculates that this is taught by Stewart et al. '458 because an improved direct surface manipulation method is disclosed which incorporates a global surface. Stewart et al. '458 discloses a DSM method for the surface parametric space where DSM features are mapped. Contrary to the Examiner's opinion, this DSM method does not teach defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In this instance, the Examiner has adduced no factual basis to support his position that it would have been obvious to one of ordinary skill in the art to modify Hirai et al. '364 by way of Stewart et al. '458 to improve shape fidelity. The Examiner's stated conclusion of obviousness is based on speculation, unfounded assumptions or hindsight reconstruction to supply deficiencies in the factual basis.

As stated in the Background of the Invention section of the present application, there is a need in the art for a system and method of direct modification of a mesh model based on DOE parameters using direct surface modeling to eliminate the need to update the CAD model each time a DOE parameter is modified. The present invention sets forth a unique and non-obvious combination of a method for design of experiments using direct surface manipulation of a mesh model in which a mesh model is updated using Direct Surface Manipulation after a DOE parameter is varied, instead of updating the CAD model and converting the updated CAD model to a mesh model.

The references, if combinable, fail to teach or suggest the combination of a method for design of experiments using direct surface manipulation of a mesh model including the steps of selecting a base mesh model from an electronic database stored in the memory of the computer system, selecting a DSM feature from an electronic database stored in the memory of the computer system, generating a mesh model using the base mesh model and the selected DSM feature, evaluating the mesh model using a computer-aided engineering (CAE) analysis, determining whether to continue generating the design of experiments response, modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function,

using the displacement of the vertex to modify the surface of the mesh model, the mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response, and using the results of the CAE analysis for the design of experiments response as claimed by Applicants.

Against this background, it is submitted that the present invention of claims 14 and 18 through 20 is not obvious in view of a proposed combination of Hirai et al. '364 and Stewart et al. '458. The references fail to teach or suggest the combination of the method for design of experiments using direct surface manipulation of a mesh model of claims 14 and 18 through 20. Therefore, it is respectfully submitted that claims 14 and 18 through 20 are not obvious and are allowable over the rejection under 35 U.S.C. § 103.

2) Claims Not Obvious or Unpatentable Under 35 U.S.C. § 103

Claims 5 and 15

As to claim 5, claim 5 claims the present invention as a method for design of experiments using direct surface manipulation of a mesh model. The method includes the step of evaluating the mesh model using computational fluid dynamics (CFD).

As to claim 15, claim 15 claims the present invention as a method for design of experiments using direct surface manipulation of a mesh model. The method also includes the step of evaluating the mesh model using computational fluid dynamics (CFD).

As to the tertiary reference applied by the Examiner, U.S. Patent No. 5,999,187 to Dehmlow et al. discloses a fly-through computer aided design method and apparatus. Computational requirements are bounded, at least in part by defining a bounded volume or world

defining the volume which may be displayed, in whole or in part. Preprocessing the data assists in organizing the data for high performance display. Full detail rendering is available. However in some situations, such as during fly-through, some or all portions of the image are rendered in a simplified fashion, e.g. to maintain a high frame rate. The volume-based simplification involves rendering faces of cells or collections of cells which are at least partly intersected by components of the item or system being displayed. A plurality of granularities, preferably organized as an octree, provide multiple levels of detail. Unnecessary rendering load is reduced by view frustum culling and considering certain cell face occlusion situations. As the scene is rendered, preferably slicewise, the level of detail for slices can be adjusted based on predictions of time-to-complete, in order to meet a frame rate target. Dehmlow et al. does not disclose evaluating a mesh model using computational fluid dynamics (CFD).

As to the differences between the prior art and the claims at issue, the primary reference to Hirai et al. '364 merely discloses a method of driving a picture display device using a Hadamard's matrix, a maximum displacement, and reference vectors. Hirai et al. lacks evaluating a mesh model using computational fluid dynamics (CFD). In Hirai et al. '364, the maximum displacement and reference vectors are used to drive a picture display, but are not used for evaluating a mesh model.

The secondary reference to Stewart et al. '458 merely discloses a system and method for forming geometric features using global reparametrization in which a mesh is ultimately substituted into a DSM method for a surface parametric space where DSM features are mapped and the shared workspace provides a common area to geometrically join topologically disconnected surfaces patches through a uniform surface reparametrization. Stewart et al. '458 lacks modifying a surface of the mesh model by varying a predetermined parameter, wherein the

surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model.

The tertiary reference Dehmlow et al. '187 merely discloses a fly-through computer aided design method and apparatus. Dehmlow et al. '187 lacks evaluating a mesh model using computational fluid dynamics (CFD). In Dehmlow et al. '187, during fly-through, some or all portions of the image are rendered in a simplified fashion, e.g. to maintain a high frame rate, but are not used to evaluate a mesh model using computational fluid dynamics (CFD).

There is absolutely no teaching of a level of skill in the vehicle design art that a method for design of experiments using direct surface manipulation of a mesh model includes the steps of converting a geometric model into a mesh mode and modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a

displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model. In addition to the absence of this teaching, the references, if combinable, fail to teach or suggest the combination of a method for design of experiments using direct surface manipulation of a mesh model including the step of evaluating the mesh model using computational fluid dynamics (CFD) as claimed by Applicants.

Obviousness under § 103 is a legal conclusion based on factual evidence (In re Fine, 837 F.2d 1071, 1073, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988), and the subjective opinion of the Examiner as to what is or is not obvious, without evidence in support thereof, does not suffice. Since the Examiner has not provided a sufficient factual basis which is supportive of his position (see In re Warner, 379 F.2d 1011, 1017, 154 U.S.P.Q. 173, 178 (C.C.P.A. 1967), cert. Denied, 389 U.S. 1057 (1968)), the rejection of claims 5 and 15 is improper.

Against this background, it is submitted that the present invention of claims 5 and 15 is not obvious in view of a proposed combination of Hirai et al. '364, Stewart et al. '458, and Dehmlow et al. '187. The references fail to teach or suggest the combination of the method for design of experiments using direct surface manipulation of a mesh model of claims 5 and 15. Therefore, it is respectfully submitted that claims 5 and 15 are not obvious and are allowable over the rejection under 35 U.S.C. § 103.

CONCLUSION

In conclusion, it is respectfully submitted that the rejections of claims 4, 5, 8 through 15, and 18 through 20 are improper and should be reversed.

Respectfully submitted,

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CLAIMS APPENDIX

The claims on appeal are as follows:

4. A method for design of experiments using direct surface manipulation of a mesh model, said method comprising the steps of:

selecting a geometric model, wherein the model is in a computer-aided design (CAD) format;

converting the geometric model into a mesh model;

evaluating the mesh model using a computer-aided engineering (CAE) analysis;

determining whether to continue generating the design of experiments response;

modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface of the model, locating a reference center within the domain, projecting a vertex located on the surface of the mesh model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model, the mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response; and

using the results of the CAE analysis for the design of experiments.

5. A method as set forth in claim 4 wherein said step of evaluating the mesh model using CAE includes using computational fluid dynamics (CFD).

8. A method as set forth in claim 4 including the step of selecting a mesh model stored in a memory of the computer system.

9. A method as set forth in claim 4 including the step of separating the surface feature modified using DSM from the mesh model and storing the DSM feature within an electronic database in the memory of the computer system.

10. A method as set forth in claim 4 including the step of modifying the deformation of a local area of the surface by changing a DSM feature parameter.

11. A method as set forth in claim 4 including the step of refining the number of elements of a surface feature modified using DSM.

12. A method as set forth in claim 8 wherein said step of selecting a CAD model and converting the CAD model into a mesh model includes the steps of:

selecting a base mesh model from an electronic database stored in the memory of the computer system;

selecting a DSM feature from an electronic database stored in the memory of the computer system; and

generating a mesh model using the base mesh model and the selected DSM feature.

13. A method as set forth in claim 8 wherein said step of selecting a CAD model and converting the CAD model into a mesh model includes the steps of selecting a DSM feature from an electronic database stored in the memory of the computer system and generating a mesh model using the converted mesh model and the selected DSM feature.

14. A method for design of experiments using direct surface manipulation of a mesh model, said method comprising the steps of:

selecting a base mesh model from an electronic database stored in the memory of the computer system;

selecting a DSM feature from an electronic database stored in the memory of the computer system;

generating a mesh model using the base mesh model and the selected DSM feature;

evaluating the mesh model using a computer-aided engineering (CAE) analysis;

determining whether to continue generating the design of experiments response;

modifying a surface of the mesh model by varying a predetermined parameter, wherein the surface is modified using direct surface manipulation (DSM) by defining a sketch plane containing a domain of a DSM feature, positioning the sketch plane relative to the surface

of the model, locating a reference center within the domain, projecting a vertex located on the surface of the model into the domain of the sketch plane, specifying a maximum displacement of the DSM feature by locating a reference vector centered at the reference center to define the height of the DSM feature in object space, specifying a basis function to determine a displacement of the vertex, determining a displacement of the vertex relative to the DSM feature using the basis function, and using the displacement of the vertex to modify the surface of the mesh model, the mesh model is updated and the updated mesh model is used in continuing generating the design of experiments response, if determined to continue generating the design of experiments response; and

using the results of the CAE analysis for the design of experiments response.

15. A method as set forth in claim 14 wherein said step of evaluating the mesh model using CAE includes using computational fluid dynamics (CFD).

18. A method as set forth in claim 14 including the step of separating the surface feature modified using DSM from the mesh model and storing the DSM feature within an electronic database in the memory of the computer system.

19. A method as set forth in claim 14 including the step of modifying the deformation of a local area of the surface by changing a DSM feature parameter.

20. A method as set forth in claim 14 including the step of refining the number of elements of a surface feature modified using DSM.

EVIDENCE APPENDIX

None

RELATED PROCEEDINGS APPENDIX

None